UNIVERSITY OF PENNSYLVANIA

VISUAL GUIDANCE IN MOTOR LEARNING

EDWARD M. TWITMYER

A THESIS
IN PSYCHOLOGY

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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VISUAL GUIDANCE IN MOTOR LEARNING

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A survey of the vast literature upon the learning process reveals a wide variance of opinion concerning its ultimate nature.[1] Many are the theories that have been propounded to explain it. At one extreme may be placed those that make learning entirely a matter of trial and error—no difference in kind between human and animal learning being admitted;[2] and at the other extreme may be placed those that admit a difference and account for certain forms of learning as dependent upon what has been called 'insight.'[3]

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[1]Because of the pressure for space the historical survey is omitted. The reader is referred to E. L. Thorndike's (*Educational Psychology*, 1913, vol. ii, Chaps. 7 and 8), and W. S. Hunter's (*Foundations of Experimental Psychology*, 1929, Chap. 15) reviews, and to the annual summaries of the literature in the *Psychological Bulletin*.

[2]Cf., for an example of this extreme view, J. F. Dashiell's account (*Fundamentals of Objective Psychology*, 1928, 333). He writes that "man's learning is like that of a cat or monkey in that it is a matter of stimuli and responses; where it differs from the latter is largely in the degree of refinement of the stimuli and in the degree of implicitness of the responses."

[3]This concept was introduced into psychology by W. Köhler (*The Mentality of Apes*, 1925), and it has since been widely accepted. K. Koffka (*The Growth of the Mind*, 1924, 214) explains it as follows: "The sudden grasping of the solution which results, is a process that runs its course in accordance with the nature of the situation, so that the complete solution of the problem takes place with reference to the configuration of the field of perception." R. M. Yerkes hss also adopted the term. He says that he uses 'insight' "to designate varietiea of experience which in us are accompaniments of sudden, effective, individually wrought adaptations to more or less distinctly new and problematic situations." (The mind of a gorilla, *Genet. Psychol Monog.*, 2, 1927, 155).

Problem

The object of the present study is to determine whether different types of learning existed. We wished to set up conditions that would permit learning with and without 'insight' and to compare the performances in the two cases. To this end we used motor learning and the pencil-maze. We used motor learning because variations in the experimental procedure may be readily made; and the maze because it has repeatedly demonstrated its usefulness in studies of this type.

A great deal of work has been done concerning the nature of the human response in the maze-situation.[4] In some experiments knowledge of the situation has been limited to the kinaesthetic experiences, in others this has been supplemented and reënforced by additional cues. The cues most generally used have guided the subjects, have lessened their dependence upon trial and error, and have permitted them to utilize a rationalized mode of attack. The cues may, therefore, be regarded as a means of facilitating 'insight.'

The majority of investigators employing supplementary cues have used some form of visual guidance. Perkins,[5] in an elaborate experimental set-up gave his subjects visual cues by having them look through a tracing tube, 1 in. in diam. and 10 in. long. "All of the field except the small range allowed by the circular opening, was cut off and the subject could see none of the field except the part of the path which lay directly at the bottom of the tube." Smith[6] likewise constructed his apparatus so as to permit his subjects a limited view of his maze. Carr used two methods:[7] in the first the maze was constructed so that the blinds, though the entire pattern was visible, were hidden from view; in the second he placed a map of the maze before his subjects. Miles devised a two-story duplicate maze, in which the subject not only saw the problem, but traced through the duplicate with one hand while performing the learning problem with the other;[8] thus receiving supplementary kinaesthetic as well as visual guidance.

Guidance adds considerably to the subject's knowledge about the problem, and may well, therefore, be said to permit 'insight' into its solution.

Specifically, the present study attempts to determine the effect of one type of visual guidance in maze learning. This type of guidance involved 'undirected intention;' that is, the subjects visually perceived others run the maze without knowing that they would, at a subsequent period, be called upon to solve it themselves.

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[4]H. A. Carr and V. C. Hicks, Human reactions in a maze, *J. Animal Behav.*, 11, 1912, 245-253.

[5]N. L. Perkins, Human reactions in a maze of fixed orientation, *Comp. Psychol. Monog.*, 4, 1927, (no. 21), 1-92.

[6]F. O. Smith, Differential reactions of human beings in the maze, *Ped. Sem.*, 34, 1927, 394-405.

[7]H. A. Carr, The influence of visual guidance in maze learning, *J. Exper. Psychol.*, 4, 1921, 399-417.

[8]W. R. Miles, The two-story duplicate maze, *J. Exper. Psychol.*, 10, 1927, 365-377.

Method and Procedure

Apparatus. A modification of Young's Slot Maze A was used,[9] the pattern of which is shown in Fig. 1. Young's pattern was not changed; the modification simply made possible its use as a pencil maze.

The maze consisted of a block of wood 25 x 26 cm., over which was fitted a smooth jacket into which the maze pattern was cut. The metal jacket was about 3 mm. thick, and it was cast with flanges which fitted snugly over the edges of

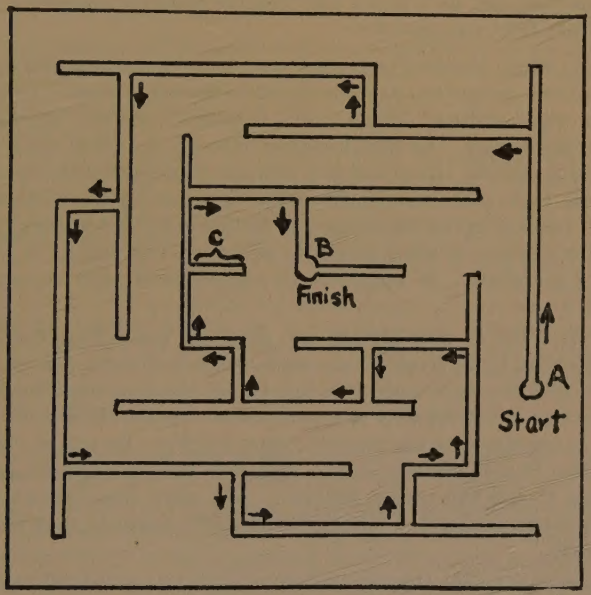

Fig. 1. Pattern of the Young Slot Maze A

the wooden base thus assuring constancy in the relative position of the two parts. By simply lifting the jacket, a piece of paper, cut to proper size, could be placed between them. The paper formed the floor of the maze and the surface upon which the *S*'s run was recorded. A hole was bored into the wooden base at the goal, consequently *S* could tell when he reached it by the fact that the pencil broke through the paper and plunged into the hole. The pathways of the maze were about 5 mm. in width, consequently only one side at a time could be followed by the pencil. This point should be noted because it, in contrast with the type in which the stylus is the width of the groove, adds to the complexity of the problem. The maze used in this experiment included 6 of the 10 desirable features listed by Knotts and Miles.[10] The features omitted were ones that could not be used in the present study.

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[9]H. H. Young, Slot maze A, *Psychol. Clin.*, 14, 1922, 73-82.

[10]J. R. Knotts and W. R. Miles, Notes of the history and construction of the stylus maze, *Ped. Sem.*, 35, 1928, 415-425.

As can be noted in Fig. 1, the pattern is such that the pathway constitutes a continuous groove from A to B with all changes in direction being right angle turns. The culs-de-sac, with one exception, c, are continuous with the direct pathways. The distances between turns and the directions of the turns are variable, so that there is no specifically related sequence in the order in which these phases of the pathway present themselves. The pattern allows for only one pathway between the start and the finish.

A pencil was used as a stylus and suitable material to make a secure and light-proof blindfold was provided.

Subjects. Three hundred undergraduate students (67 men and 233 women), divided into two groups of 150 each, served in the experiment. At the time the experiment was conducted, every *S* had completed one and one-half years of elementary psychology. All were members of one of the three upper classes, the majority being juniors. None had had previous experience with the maze. Over 500 students performed some or all of the experiments, the elimination which determined the final group being based on factors of non-conformity to the above mentioned conditions, or some inequality of factors with respect to the standard methods of procedure. *S*s not normally right-handed were among the group eliminated.

Procedure. The *S*s were divided into groups of two. They worked at three periods separated by intervals of one week. One *S* of every pair performed the experiment with the maze during the first two of the three experimental periods; the other acting in the capacity of experimenter. At the third period the *S* who had acted as experimenter was given the maze to solve. He was of course assisted in his solution by the 'visual guidance' obtained from watching his partner solve the problem at the two earlier periods.[11] The work was done as part of the regular laboratory course.[12] Collection of the data began in 1925 and was completed in 1929.

The procedure on the three experimental days was specifically as follows.

First period. When a given class presented itself for the experiment on the first day, it was divided into two groups, the division being made by two individuals volitionally pairing themselves, with the understanding that such arrangement would continue until the completion of the experiment. Every individual thereby became a prospective member of what will be called hereafter Group I or Group II. The entire group was then informed that Group I was to

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[11]H. A. Carr (*op. cit.*) uses the term 'post-visual guidance' with the recognition that this term involves a memorial phase. Carr's method of supplying this form of guidance, while satisfactory for his study, does not allow an evaluation of that phase in the present research. Inasmuch as the guidance referred to in this study is obtained by visual perception, together with the fact that the relation between perceptual and post-perceptual guidance is not of present interest, the term 'visual guidance' will be used throughout this report.

[12]The method follows that outlined by Professor Karl G. Miller who was responsible for inserting this experiment in the laboratory course. The writer wishes to express his appreciation for the many helpful and timely suggestions made by Professor Miller and for his coöperation in this study.

do a learning problem with a maze without the aid of vision, and that Group II was to do a learning problem with card-sorting.[13] The members of every pair were then allowed to select the type of problem they preferred to do and in most cases the decision was reached by the tossing of a coin. Group I (Maze) was then temporarily dismissed from the room, Group II (Card-Sorting) remaining to be given the instructions by which they would act as experimenters with their partners in tracing the maze. The maze was then shown to Group II and the following instructions read:

"When your partner (*S*) returns to the room and all of Group I have been securely blindfolded, you will be given a maze similar to this one, which you will place before *S*, with the starting point at the right making the first movement of *S* in a direction away from him (cf. Fig. 1). The *S*s will be instructed by me as to the nature of their task. You will place a pencil in *S*'s right hand and guide it in the starting point of the maze. When *S* completes the tracing by reaching the goal, you will take the pencil from the maze and record the time consumed in completing the tracing. One tracing from start to finish will constitute a trial and *S* is to complete 15 trials as his work for the day. You are to keep a time-record of each trial. *S* is at no time to be aided by you, other than at the start and the finish. If *S* gets out of a pathway at any time, replace the pencil at the point it left the path and instruct him to keep on working. Be sure the pencil is held so that no part of the hand comes in contact with the board. The left hand is to be placed along the edge of the board, but at no time must it come in contact with the pattern. Do not tell *S* how many trials he has to do or how many have been completed. Remember you are to give no information and under no circumstance is *S* to see the maze pattern. When he has completed 15 trials place the maze face down in another part of the room."

Questions concerning the instructions were then answered and any doubts concerning the method of procedure were made clear. Group II was then given its method of procedure for the card-sorting to be done when the maze problem was completed and with the members of Group I, in turn, acting as experimenters. These were given directly to the members of Group II to avoid confusion or delay upon the return to the room of Group I and they were instructed to explain the card-sorting procedure to their partners.

Group I was then brought into the room and the following instructions were read.

"You are going to be given a maze problem to do blindfolded, and your partner has been instructed in the required method of guiding your work. Do not ask any questions for none will be answered. The problem is yours to solve by your own adaptation to its nature. A pencil will be placed in your right hand and with it you are to trace your way from the starting point through a series of paths until you come to the end. When you have reached this end or goal, the fact will be made known to you. You are to continue in your efforts from start to finish as the time which is required by you in your tracing will be recorded by your partner. Remember you are to ask no questions and do absolutely what you are told to do by your partner."

The members of Group I were then blindfolded and allowed to adjust themselves comfortably before a table on which the maze was placed. The distance of

[13]The procedure in the card-sorting is omitted inasmuch as it is not a part of the data presented in this study. It was so arranged as to constitute an experimental problem equal in importance to that created by the maze situation. Thus each individual in a pair had his own problem to do.

the individual from the maze was suited to the convenience of *S*. Stop watches and clocks were used as timing devices. If *S* requested a rest period between trials, it was granted, otherwise the trials followed one after the other. During the course of the experiment the writer and some one assisting him were in attendance to see that all conditions of the procedure were adhered to.[14] When the members of Group I had completed the maze problem, Group II worked and completed the task of card-sorting, and the class was dismissed.

Second period. During the second experimental period, which was one week later than the first, Group I again did the maze problem, and Group II continued the card-sorting. Group I was dismissed from the room and the instructions for the work of the day given to Group II.

Under the same conditions as of the previous experimental period each member of Group II was instructed to have his partner do 15 trials of the maze in the following order: 5 trials in the same manner done previously, that is, with the right hand and with the starting point at the right; then 5 trials with the left hand, the maze board remaining in the same position; and finally 5 trials were to be made with the right hand with the board turned at an angle of 180°. This, of course, reversed the direction of all the pathways and made the starting point at the left of the board instead of the right. No indication of these variations were given *S*, his realization of the difference being a part of his adaptation to the situation. A record of the time for each trial was to be noted.

Group I was then called into the room and told that they would again have a maze to do blindfolded. When this was completed by Group I, Group II continued their problem in card-sorting, which likewise had variations as contrasted with the procedure of the first period. As on the first day the maze pattern was not seen at any time by Group I.

Third period. At the start of the third experimental period, which fell one week after the second, the members of Group II who up to this time had been acting as experimenters for the *S*s on the maze and had themselves been working at card-sorting, were informed that they were to do the maze. They were told that it was going to be presented to them under the same conditions as they had given it to the members of Group I at the first period and during the first 5 trials of the second period. This was the first intimation to the members of Group II that they were to act as *S*s on the maze. They were not allowed to see the maze and were immediately blindfolded and given 10 trials. The members of Group II, therefore, had not seen the maze since they had acted as experimenters for the members of Group I, one week previous to this third period. The time of each trial was recorded.

In carrying out the above procedure for the entire experimental group, 4 *S*s were encountered who failed completely to master the maze. Others were given aid when it became obvious that the problem was causing an emotional upset. Finally, certain *S*s varied in several ways from the standard methods, such as missing a given period, not following instructions, etc. In all such cases the results of both individuals in the pair were eliminated from the study. The writer watched very closely for signs in Group II which might indicate an expectancy of doing the maze problem in the third period. If such was suspected, and in some cases it was no more than a suspicion, the results were discarded. The writer fully believes from his observations and reports from various *S*s that a situation

[14]The group were under constant supervision. Not more than 10 *S*s participated in the experiment at one time.

of 'undirected intention' was created for Group II. This belief is based on the following conditions: first, by conducting the experiment in the form of a regular classroom duty; secondly, by giving the members of Group II a particular task (card-sorting) to perform during their periods of observation of the maze; thirdly, by keeping the maze from members of Group I at the end of their second period and thus intimating that they would be called upon to work on it again at the next period; and fourthly, the expressions of surprise which were displayed by members of Group II when informed on the third day as to the nature of their task.

Results

In considering the results of the present study, it should be noted that in any given part a complete mastery of the maze situation was not required of the *S*s, and that the data herein presented pertain only to the early acquisitional stages of the learning curves representative of the conditions investigated. Thus the 'number of trials' made for the several parts is not a function of the individual maze adaptability of the various *S*s; but rather arbitrary criteria chosen following a set of preliminary experiments. This phase of the results, therefore, assumes the rôle of a constant factor in the following analysis.

From a qualitative point of view, several aspects of the responses elicited are of importance. They have their origin either in the mode of attack selected by the *S*s or in certain types of solution to which the maze utilized was particularly adapted. It can be noticed by referring to the diagram of the maze pattern (Fig. 1) that it is possible to reach the goal and include all of the blind alleys in the pathway. This was one method used by a number of *S*s, particularly those in Group I. They would rush through a path until stopped by the cul-de-sac segment and then retrace to the opening. In such cases the error part of the pattern formed the cue which was learned rather than the correct pattern. Some *S*s used a modification of this method. That is, they definitely established certain turns avoiding the cul-de-sac at that point, but at other sections made the blind a part of the path. The fact that the point of the pencil used could only be in contact with one side of the groove allowed for many variations in the methods. Some definitely chose one side of the path as a guide, while others learned to fluctuate the pencil from one side to the other, seeking a break as the cue. In some cases this obtained the desired result, but in others the amount of forward motion injected into this procedure carried them past the correct turn and into a blind. Some rushed through the middle of the path

and disregarded the edges as guides entirely. Finally there were those who established the correct pathway and completed the pattern with none or few errors. All of these variations in method applied to *S*s of both groups. Thus the matter of errors in a given trial gave little and in some cases no indication of the ability of the individual to solve the situation, namely to trace from the start to the goal. Rather, the qualitative aspect became bettered in terms of the speed with which a given individual adapted himself to a given method, for under those conditions he more readily attained a solution. Hence a quantitative evaluation of errors as a means of presenting a picture of the qualitative aspects did not seem warranted.

The speed of learning seemed to be a more constant means of measurement under the conditions enumerated and for that reason the time required for a given trial is used for quantitative presentation of the results.

This is done in terms of the average for any given trial, for which the mean variation is indicated along with the percentage of variability which it represents. Inasmuch as extreme variability, especially during the initial stages of maze learning, seems to be a function of that type of problem, other measures which might tend to lessen the influence of such cases on the group results are not presented.

First period. Group I had as its problem 15 trials of the maze to do blindfolded with the right hand. Thus the task was one which was 'motor' in its nature. Table I indicates the results which were obtained. The first three columns are the average times in sec. per trial for 3 groups of 50 *S*s, selected in the order of their completion of the experiment. The fourth column represents the cumulative average per trial for the entire group, the fifth, the mean variation for each trial. The last column shows the percent variation. Curves A and A′ in Fig. 2 show graphically the cumulative averages and mean variations in sec., the solid line represents the former, and the broken line the latter.

The results are typical of the acquisition stages for a problem of this type. The curve shows a very high phase at the start, with a rapid drop and tendency to flatten as the number of trials increases. It is characteristic of the trial-and-error method of approach to the maze situation with adaptation through repetitive performance. The curve shows one inversion, that appearing on the twelfth trial. No

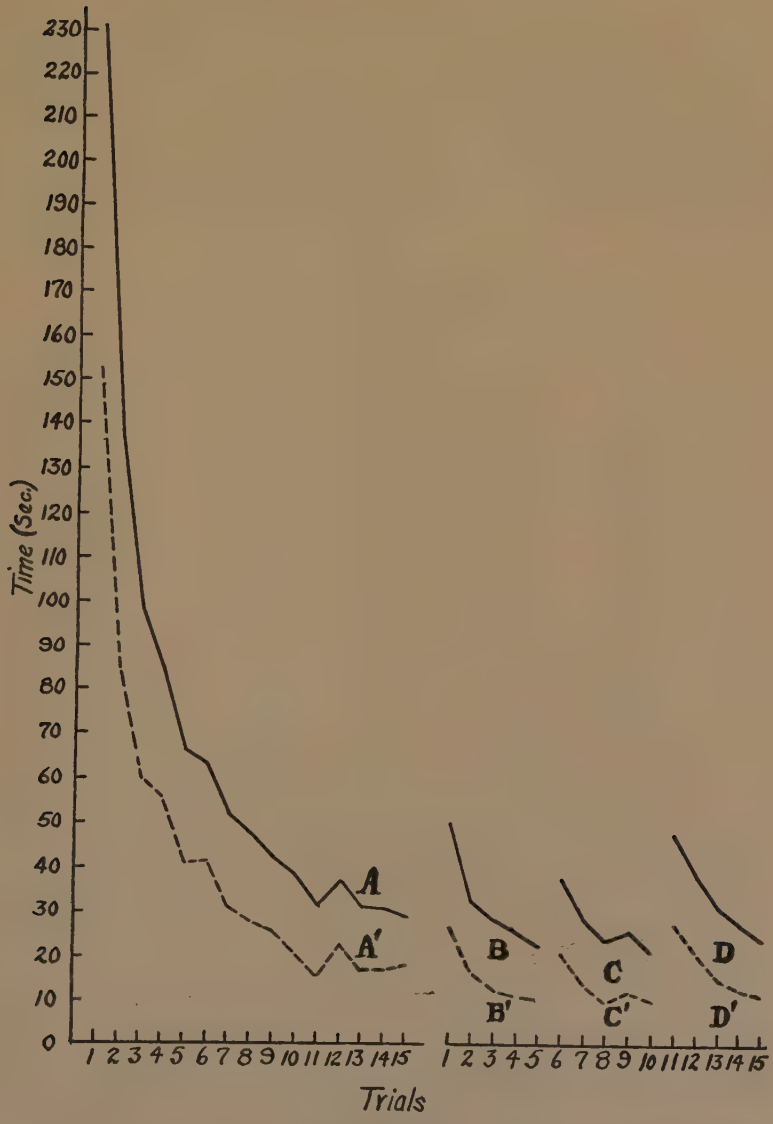

FIG. 2. CURVES SHOWING, FOR EVERY TRIAL IN THE FIRST AND SECOND EXPERIMENTAL PERIODS, THE AVERAGE TIME TAKEN BY THE 150 *S*s OF GROUP I TO SOLVE THE MAZE-PROBLEM TOGETHER WITH THE M.V. OF THEIR PERFORMANCES

(Solid lines represents average time; broken lines, m.v. The A curves were obtained in the first experimental period and the B, C, and D curves in the second)

significance can be attached to the trial. From Table I it can be noticed that for the first group of 50 *Ss* there is an inversion on the twelfth trial, for the second group three inversions on the sixth, twelfth and fourteenth trials while the third group shows one inversion on the last trial given. A certain amount of temporary unrest was general during the last 5 trials for many of the *Ss*, so that regressions in the learning attitude seem justified at any point during

TABLE I

RESULTS OF GROUP I, FIRST EXPERIMENTAL PERIOD
(Average time of performance, expressed in sec.)

Trials	1st 50 *Ss*	2nd 50 *Ss*	3rd 50 *Ss*	Total no. *Ss* Ave.	M.V.	Percent variation
1	191.0	210.7	293.0	231.5	153.0	66%
2	123.0	135.9	154.1	137.6	85.8	62
3	95.7	91.3	109.2	98.7	60.5	61
4	78.0	82.8	94.7	85.1	55.8	66
5	63.7	60.9	75.8	66.8	41.0	61
6	46.9	69.9	73.3	63.3	41.8	66
7	41.2	61.1	54.8	52.3	31.0	59
8	37.0	55.5	49.2	47.2	27.2	58
9	34.9	50.3	42.1	42.4	25.1	59
10	31.9	49.7	35.1	38.9	21.7	56
11	27.9	37.5	32.0	32.4	15.4	48
12	35.7	43.8	30.5	36.6	23.1	63
13	29.6	36.7	28.7	31.6	16.4	52
14	26.2	39.7	26.1	30.6	16.4	54
15	29.5	32.5	27.5	29.8	17.2	58

these stages. The regression on the sixth trial for the second group of 50 *Ss* seems to indicate that the trial-and-error method is still highly operative. The inclusion of enough cases keeps the cumulative curve positively accelerated at this phase.

An inspection of the results reveals the extreme variability which accompanies human reactions to the maze. During one trial the mean variation drops to 48% but at no other time is it under 50%. During the first, fourth, and sixth trials it reaches 66%. The dotted curve in Fig. 2 indicates the relative constancy of the variability throughout the 15 trials.

Second period. The *Ss* working upon the maze during the second period were those who had the week previous completed 15 trials of the maze with the right hand. Their task for the second period of work was divided into three phases, the results being given in Table II, and graphically by Curves B, B′, C, C′, D, and D′ in Fig. 2. These results are presented in the same form as described for the first experimental period.

The procedure for the first 5 trials of the maze duplicated that of the previous session. An inspection of this part of Table II and Curve B, Fig. 2, indicates the nature of response. The average time for the first trial was 50 sec., that for the fifth trial 23.3 sec., the character of the curve showing a continuous decrease between these two limits, with a rapid drop at the start. The curve itself is indicative of an increasing adaptation to the task.

TABLE II

RESULTS OF GROUP I, SECOND EXPERIMENTAL PERIOD
(Average time of performance expressed in sec.)

				Total no. *Ss*		
Trials	1st 50 *Ss*	2nd 50 *Ss*	3rd 50 *Ss*	Ave.	M.V.	Percent variation
1	48.6	48.7	52.8	50.0	26.5	53
2	32.2	33.8	33.0	33.0	16.0	48
3	26.7	29.4	28.2	28.1	13.2	47
4	23.8	28.2	25.9	25.9	12.4	48
5	20.5	27.9	21.7	23.3	10.5	45
1	31.4	38.4	41.4	37.0	21.2	57
2	26.0	31.3	28.6	28.6	14.1	49
3	20.3	28.9	23.2	24.1	10.0	41
4	22.3	28.3	26.2	25.6	12.8	50
5	20.1	26.7	21.1	22.6	10.5	46
1	41.2	45.2	56.7	47.7	27.1	57
2	41.8	34.8	43.3	39.9	21.7	54
3	26.3	34.7	33.4	31.4	15.2	48
4	22.8	29.4	30.5	27.5	13.4	49
5	22.6	25.2	25.6	24.4	11.5	47

Comparing these results with those of the first period reveals certain points of importance. The start of Curve B is extremely lower than that of Curve A. The actual time difference between the averages of the corresponding first trials amounts to 181.5 sec. The first trial for Curve B compares with that of the seventh trial of Curve A, while the second trial compares with the eleventh trial, disregarding the inversion at the twelfth trial of A. These facts indicate a beneficial result which the previous experience during the first period exerted a week later on the same problem. At the same time the start of Curve B appears to be higher than the point attained in Curve A at the fifteenth trial. Fifty seconds was required for the first trial at the start of the second period, 40% of which is in excess of the time used in completing the last trial during the previous period. This 40% then may be said to represent the amount of forgetting which occurred during the one week interval. A further

inspection of Curve B shows its last 3 trials to be more efficient than any of the trials in Curve A. Hence following the re-adjustment to the situation during the first two trials, the group continued to learn the maze, and indicated by these results that the problem had not been fully learned during the first period.

The mean variations throughout these 5 trials remain high, ranging between 45% and 53%. Despite the extreme variability for this part of the experiment, it is less than that during any part of the first period. While the difference is not great, a tendency toward decrease in variability may be said to be exhibited.

The second phase of the work during this period is represented by the second group of 5 trials inclusive and by Curves C and C′. This followed immediately the first 5 trials and involved one change in the procedure, namely the use of the left hand for tracing instead of the right. Indications of bilateral transfer from hand to hand in one direction and interference with the adaptive reactions to the maze as a result of this modification may be sought.

The previous 5 trials, as shown by Curve B, have indicated that the continuance of acquisition of the original problem had become reëstablished after one week and that the form of its progression was proceeding normally. A comparison between Curves B and C is therefore warranted. Curve C starts lower than B, showing under the conditions a more effective initial adaptation to this situation than that caused by absence from the maze pattern for one week. By the third trial, Curve C is practically the same as the corresponding point on Curve B, and the same is true for the fifth trials. The first trial of C is higher than the final stage of B, this difference amounting to 37% of the time consumed in the initial trial with the left hand. One inversion appears in Curve C on the fourth trial but this is slight and the curve assumes its normal trend immediately. If we compare C and A we note the great difference existing between the initial stages. This amounts to an actual saving of 194.5 sec. between the first two trials. The first trial of C compares in actual time with the tenth trial of A, and as it has been pointed out through the comparison with B, its last trial is lower than that of A. These results then indicate a great degree of transfer from right to left hand and an apparent continuation of acquisition under this condition. The only indication of interference appears in the first two trials of Curve C, but its influence is rapidly overcome in succeeding trials

and it would seem to have a negative value in terms of the acquisition of the maze problem. At the most it proves to be of a temporary nature.

The variability during this phase continues to remain high. For one trial it is 41%, but for the other four ranges from 46% to 57%. This is slightly higher than for the first 5 trials in this period, but the difference does not seem significant. Rather it denotes the constancy of high variation which accompanies human maze response.

The final phase of the second working period involved a solution of the maze with the right hand, but with the board rotated 180°. This followed immediately the five trials with the left hand. Curves D and D′ in Fig. 2 represent this problem. We find the start of Curve D to be slightly lower than that of B but higher than that of C, and progressing in a normal manner to practically the same level as both at the end. Its first trial compares with that of Curve B, while its second trial approaches the first trial of C. The time of the first trial of Curve C is 52% in excess of the last trial for the previous task (Curve C) and 50% in excess of the last trial of Curve B. This might seem to indicate that the interposition of 5 trials with the left hand had little effect on the third phase and that this increase in time points more directly to the change in position of the pattern. In terms of Curve A, the rotation of the pattern caused no marked interference and the carry over of the beneficial results of that period of experience is readily discernible. As in the case of Curve C, representative of a time interval lapse in the problem, and Curve B involving a change of hands, Curve D shows only temporary interference at the start with a rapid readjustment to the continuance of acquisition. It should be noted that all three curves end at practically the same level, which is lower than the final level of Curve A, and that they all give evidence that the learning of the maze is still in its acquisition stages at these points.

For the third phase the variability follows the same trend which marked its display during the previous trials. It again shows itself to be high, its range showing limits of 57% and 47%. The variability then for the entire fifteen trials of this period remains high and fairly constant, with a tendency toward a decrease only during the first five trials, which does not seem significant.

Third period. The work in the third period was done by Group II. These *Ss* did 10 trials of the maze under the conditions previously

described as creating for them visual guidance with 'undirected intention.' Table III shows their results in the same manner as heretofore, with one addition. The last column indicates the percentage gain of a given trial for this group as compared with the corresponding trial for the first period of Group I.

TABLE III

RESULTS OF GROUP II, THIRD EXPERIMENTAL PERIOD
(Average time of performance, expressed in sec.)

Trials	1st 50 *Ss*	2nd 50 *Ss*	3rd 50 *Ss*	Total no. *Ss* Ave.	M.V.	Percent variation	% gain per trial
1	73.2	54.6	69.0	65.6	34.6	53	71.7
2	50.7	40.2	48.0	46.3	22.2	48	66.3
3	40.2	36.6	37.1	37.9	16.3	43	61.6
4	32.1	31.9	33.4	32.4	13.3	41	61.9
5	27.9	30.3	29.3	29.1	11.1	38	56.4
6	24.4	27.2	26.0	25.8	9.4	36	59.2
7	27.2	27.6	24.1	26.3	9.8	37	49.7
8	22.9	21.8	21.3	22.0	8.3	38	53.3
9	21.8	20.4	21.0	21.0	7.2	34	50.4
10	19.6	18.4	19.8	19.2	6.8	35	50.6

Curves E and E′ (Fig. 3) show graphically the form of the acquisition stage for Group II, with its corresponding curve of variability. It can be noted that the curve is characteristic in its nature with large initial drops as compared to its final stages. Attention is called to the fact that the average time for the first trial is 65.5 sec. and that within 10 trials the average decreases to 19.7 sec. The significance of this low starting point and final stage will be discussed later.

The variability curve (Curve E′) shows a decrease in relation to the time curve. The decrease ranges from 53% on the first trial to 35% on the tenth trial. (Table III). This also will be discussed later.

Since the third period involves the first 10 trials of Group II on the maze, a comparison of these results should be made with the similar part of the maze problem for Group I. In this respect Group I forms the control group. Such a comparison is shown graphically by the curves in Fig. 4. Curves A and A′ are those for Group I, while E and E′ represent the average times and mean variations for Group II. The effect of the conditions under which Group II did its first trial may be noticed by the actual decrease of 166 sec. which it shows over the corresponding trial for Group I. This amounts to a saving for Group II of 71.7%. By the same means of comparison

for each of the remaining nine corresponding trials, the saving for any given trial may be ascertained. These values are indicated in the last column of Table II. The least amount of saving for any trial is 49.7% on the seventh, while the tenth trial shows 50.6%. By the fifth trial Group II had decreased their actual time value to 29.1 sec., while the lowest time made by Group I during its first period was 29.8 sec., reached on its fifteenth trial. The lowest time made by Group II was 19.2 sec., reached on its tenth and last trial. This is 10.6 sec. faster than the lowest average shown for Group I on its fifteenth trial. The actual time advantage which Group II had for the corresponding tenth trial was 19.7 sec. If we compare the average times for the two groups as indicative of trials saved by Group II, the results would indicate a saving of the first 5 trials used by Group I. This is shown graphically in Fig. 5, by transposing Curve E (Group II) so that it starts at the sixth trial of Curve A (Group II). This transposition also presents graphically the actual superiority which the curve for Group II maintains over the last 10 trials of Group I.

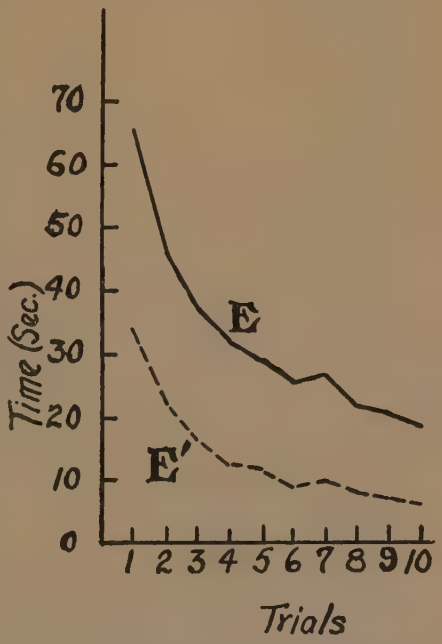

FIG. 3. CURVES SHOWING, FOR EVERY TRIAL IN THE THIRD EXPERIMENTAL PERIOD, THE AVERAGE TIME TAKEN BY THE 150 *Ss* OF GROUP II TO SOLVE THE MAZE-PROBLEM TOGETHER WITH THE M. V. OF THEIR PERFORMANCES
(Solid line represents average time; broken line, m.v.)

The decrease in the percent variability between the two groups is conspicuous, although Group II never shows a mean variation any lower than 34%. Whereas Group I in its first 10 trials shows a range of 56% to 66% variability, the range of a similar period for Group II is 34% to 53%. During the first 5 trials for Group I, the variability is never less than 61%, while all but the first trial of the corresponding series for Group II is under 50%, the fifth trial being 38%.

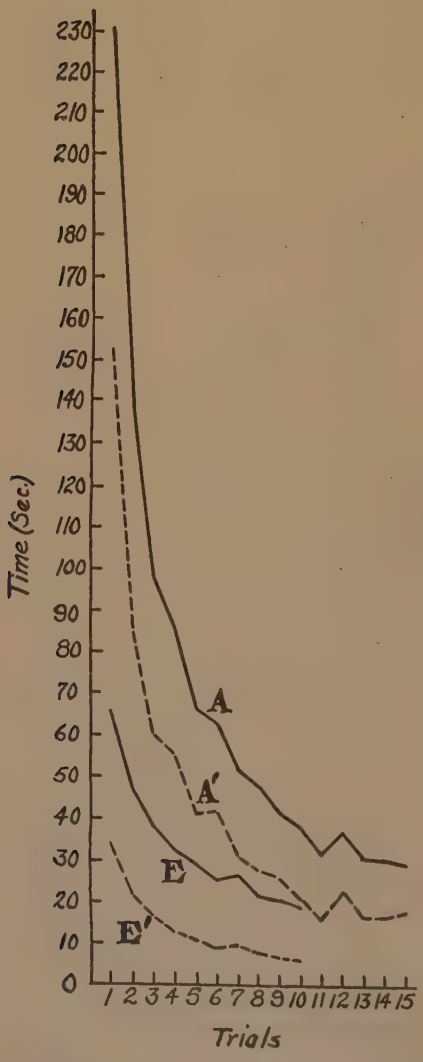

FIG. 4. CURVES COMPARING THE PERFORMANCES OF GROUP II WITH THE FIRST 10 TRIALS OF GROUP I IN THE FIRST EXPERIMENTAL PERIOD

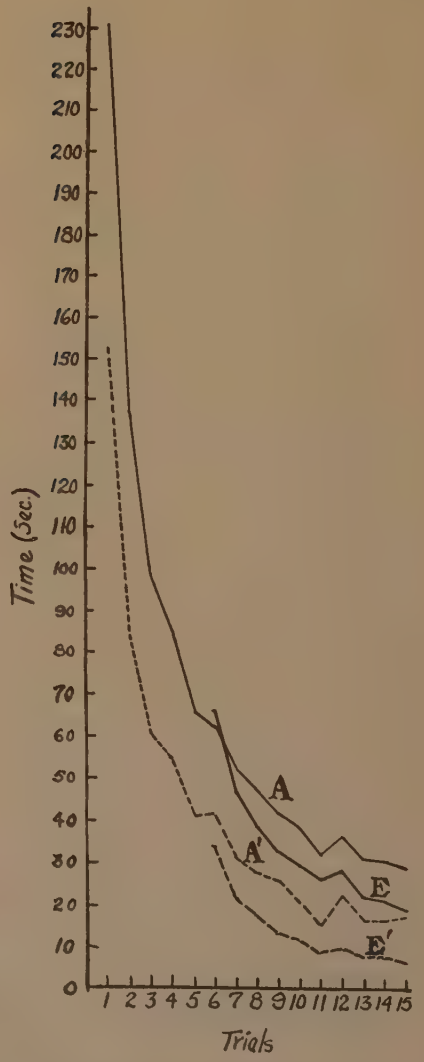

FIG. 5. CURVES COMPARING THE PERFORMANCES OF GROUP II WITH THE LAST 10 TRIALS OF GROUP I IN THE FIRST EXPERIMENTAL PERIOD

(Curves A and A′ show results of Group I; E and E′ the results of Group II. Solid lines represent average time of performance; broken lines the m.v.)

Thus the results show Group II to be superior to Group I during the initial acquisition stages of the two learning curves. This is indicated by the relative percentage of saving for the corresponding trials, the actual speed attained by Group II (superior to even the fifteenth trial of Group I) and by the decrease in the percentage of variability.

The results obtained from Group II lend themselves to a comparison with those obtained during another phase of the work done by Group I. That is, the first 5 trials for Group II may be analyzed with respect to the first 5 trials given Group I at the second period. Group I had at the start of its second session the background for the maze situation resulting from its experience during the 15 trials, completed one week previous. Group II (visual guidance) had witnessed 30 trials done by Group I under the conditions already referred to, their last period of visual observation likewise having occurred a week previous to their actual work with the maze. In Fig. 6 Curves E and E′ are those of Group II, while Curves B and B′ are those of Group I for the 5 trials mentioned above.

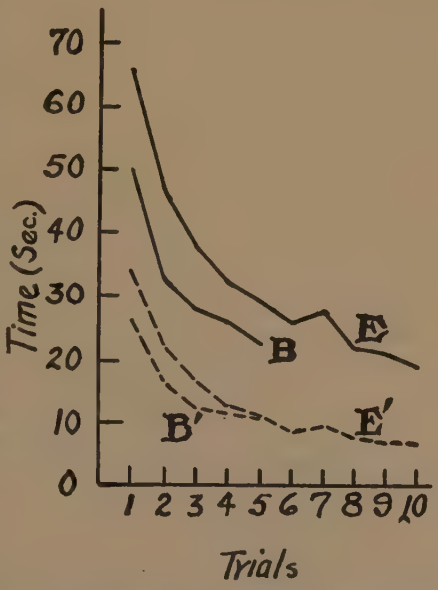

FIG. 6. CURVES COMPARING THE PERFORMANCE OF GROUP II WITH THE FIRST 5 TRIALS OF GROUP I IN THE SECOND EXPERIMENTAL PERIOD

(Curves B and B′ shows results of Group I; E and E′ the results of Group II. Solid lines represent average time of performance, broken lines the m.v.)

From an inspection of the Curves B and E it can be seen that Group I is superior to Group II throughout. For the first trial Group I (Curve B) shows an average time of 15.5 sec. less than that of Group II (Curve E), which equals 23%. For the remaining 4 trials, differences in favor of Group I continue and amount respectively to 28%, 25%, 20%, and 19%. On the basis of this analysis, the 15 trials of actual maze experience gave Group I an advantage in speed of acquisition when this was continued at a later time, as

compared to the visual guidance supplied Group II for their initial attempts at the problem. It should be noted that Group II had actually observed 30 trials of the maze and due to the actual pairing of *Ss* their time period of observation of performance doubled that of Group I, not only as a group but individually.

Both groups showed a mean variation of 53% for the first trials. After remaining the same for the second trials (48%) Group I showed a decrease to 45% on its fifth trial, while Group II showed a variability of 38% on the corresponding trial. This would indicate a slight tendency of superiority in this respect for Group II.

Discussion of Results

The interest of the study herein presented centers around the effect of visual guidance on the acquisition stages of a motor learning problem, more specifically that of maze adaptation by humans. In addition, the question of such effect as it might exert itself through a procedure involving what has been termed 'undirected intention' is a part of that interest. Obviously a motor problem such as maze tracing is one in which any cues effecting a more efficient performance must come through actual experience with that situation. In terms of actual sensory experience and discrimination involved, such learning becomes dependent on kinaesthetic and tactual perceptions. The learning process in this case is functioning minus the activity which would accrue from a possibility of visually perceiving the task, and as such is functioning in a manner not most common to its normal operative status. Miles,[15] by his statement that, "vision is the critical supervising partner in nearly all perceptual situations" most aptly gives significance to the condition where that sensory channel is eliminated. Basically there are a number of elements common to both situations, regardless of the 'theory of learning' accepted, and an experimental investigation which allows for a comparison and interpretations suggested by such means, seems justifiable.

The two groups which have been studied and which may be said to represent the two conditions explained above gave objective results which were very different. The one during its acquisition stage displayed a method which was most characteristic of 'motor' learning. They attacked the problem by a series of random movements, some of which brought success, while others did not, and only in terms of a

[15]W. R. Miles, The two-story duplicate maze, *J. Exper. Psychol.*, 10, 1927, 365-377.

number of repetitive performances did they establish a more efficient adaptation. As a result of this method of attack, they attained relatively large increases in efficiency during the early trials, but at the same time their initial acquisition times were far in excess of the visually guided group. At the end of an equal number of trials the difference between the two groups remained large. This was not only true relatively but in actual time required to trace the maze. As we have pointed out under the results, the percentage of time saved by the visually guided group was never less than 49%, while for the first trial it amounted to 71%. The variability between the two groups showed the visually guided group to be more stable in their attack on the problem. The emotional response which was present in Group I, due to the inability to estimate the degree of success and clear knowledge of the nature of the problem, was most noticeably absent in the visually guided group. In all respects which served as criteria of comparison between the two groups, the acquisition of the problem showed the visually guided subjects to be superior.

Such a difference could be brought about by inequality of maze ability among the constituents of each group. Chance also offers a means of obtaining differential results in learning of a maze problem. Heron has indicated how both these factors may function in influencing results.[16] The writer does not believe that these factors account for the difference revealed. Objective dissimilarities in the nature of the problem would be causal factors determining a difference, but again under the conditions of the experiment this interpretation does not seem warranted.

Earlier, the writer has referred to other investigators who used methods of visual guidance and the nature of the results obtained in this study are in general agreement with their findings. The method used here, however, differs noticeably in two ways: first, the reactions from which the results were obtained remained in the form of a normal maze situation in all respects; and secondly, a form of complete visual guidance was supplied, and by this we mean the *S* not only perceived the entire situation but also had the opportunity to observe the type of correct and incorrect responses in operation. As has been noted, to gain these effects the guidance was post-visual in its degree. Under these conditions, then, the validity of the state-

[16]W. T. Heron, Individual differences in ability vs. chance in learning the stylus maze, *Comp. Psychol. Monog.*, 2, 1924, 1-60.

ment that the visual guidance supplied was the most effective cause for the superiority of the second group seems justified.

It is interesting to note one or two conclusions which might be inferred as to the actual difference in the functioning of the learning process responsible for the degree of dissimilarity in the results. For the Gestalt group a situation would seem to have been created with an added 'insight' into the nature of the task. The visual guidance would seem to have allowed for a more intelligent type of learning as contrasted with that dependent on chance, for the configuration involved would be given a greater completeness. Of course in this respect, as the visual guidance was not of a perceptual nature at the time the second group was actually doing the maze, their behavior would not take place with complete 'insight' and so they would be only partially better than the non-guided group. This is what the results of this part of the study show. Hunter concludes that the Gestalt conditions allowing for 'insight' "are fulfilled only with visual stimuli and the result is that insight would thus be limited to visually determined behavior. This in itself leads one to question the hypothesis, for it is highly doubtful that so important a factor as insight is alleged to be would be limited in this manner."[17] Hunter feels that "no causal factor of insight has been demonstrated," and concludes that it is not necessary to set up two kinds of learning as opposed to that which results from "the modification of behavior as a result of repeated stimulation under specified conditions."[18] Another comparison between the two groups in this investigation would tend to show that a higher degree of acquisition of the maze problem can be attained in less time by actual performance with no visual guidance. This would tend to support some of Hunter's conclusions.

When the non-visually guided group performed the maze for 5 trials after a lapse of one week, they showed a more advanced stage of acquisition than did the visually guided group on their initial 5 trials. Both groups were equal in that their last experience with the maze had been one week previous. But the individuals of the non-visual group had worked through but 15 trials and had consumed only one half the time which the visual group had exercised in observing 30 trials. It therefore seems that actual practice with the maze situation had a greater influence on the factors in the learning

[17]W. S. Hunter, *The Foundations of Experimental Psychology*, 1929, 576.
[18]Hunter, *ibid.*, 581.

process than did the visual guidance under the conditions herein presented. If the inference is to be made that the so-called factor of 'insight' by visual guidance made Group II more proficient in a given stage of acquisition, then it must be admitted that the attainment of that same level, by Group I, under the procedure used here warrants an assumption of an 'insight' factor in their method of learning when that level is reached. In this case, of course, this subjective state has been reached without any visual perception of the problem. This would support Hunter's claim that so called intelligent behavior in the learning process is not necessarily limited by visual perception. It would also seem to indicate that the learning process underlying the displays given by both groups were essentially the same kind. The writer believes this to be true.

It seems logical that the acquisition of a maze habit can be made more efficient through familiarity with all of the factors involved in its solution. This familiarity would seem to depend on the degree with which an individual becomes both mentally and physically oriented to the problem it represents. This experiment suggests that visual guidance supplies more quickly, at the start, necessary components of that orientation and therefore the acquisition stages under such conditions exhibit a high degree of objective adaptation. At the same time, it also suggests that part of the orientation comes through actual maze experience, for the curve achieved under such conditions, while relatively more efficient, shows much the same form as that of the non-visually guided. Further, this study tends to indicate that the same degree of orientation may be gained through actual experience in a maze situation in less time. Probably the difference in the actual functioning of the learning process is one which is explained in terms of its 'manner' of operating and not that involving another 'kind' of learning.

The procedure followed in this study made for conditions which have been termed 'undirected intention,' for the visually-guided group. It is *assumed* that during their period of observation they were not doing so with the intent to learn the maze for future experience. As we have stated, this attitude seemed to exist on the part of the *S*s, although a comparative study should be made under which a 'directed intention' attitude to learn is definitely established. In view of the fact that any evidence of a 'directed intention' eliminated an *S* from the group studied and likewise because no objective

factors of a 'directed intention' were a part of the procedure, it is believed that the result of visual guidance may be said to have become effective in those terms. No statement, however, is made as to the degree of influence which this exerted on the results of the study.

The results indicating transfer from right to left hand and lack of interference by rotating the maze board 180° show an agreement with workers who have investigated these same phases under more controlled and specific conditions. Ewert[19] and Bray[20] have experimentally shown the possibility of bilateral transfer. In this study the change of hands caused practically no interference and the group continued to progress in its learning of the maze. The same may be said of the change of position of the board. Hunter found practically no interference due to such a change,[21] a similar conclusion to the one indicated by the results of this study. In addition, the amount of forgetting over a period of one week can be noted by comparing the results of Group I in their first two experimental periods. Presented with the same problem as the previous week, the group showed at the start of this problem a loss of 40% in time, but by the third trial acquisition was proceeding more efficiently than at any trial during the first period. Thus, what forgetting occurred exerted only a temporary influence on the group's tendency to continue to learn. The last three phases of the problem have been discussed but briefly, a more complete interpretation being shown under the results. Their main purpose in the experiment was to furnish further means of comparison with Group II and to serve the purpose of a complete form of visual guidance.

Finally, the high variability which is to be found in problems of the maze type was apparent through all parts of this study. This seems highly indicative of the type of solution which the maze requires and obviously has a high interpretative value with regard to the manner in which the learning process functions in this kind of task.

Conclusions

Summarizing then in a more specific manner the conclusions suggested by this experiment, we might list the following:

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[19]P. H. Ewert, Bilateral transfer in mirror drawing, *Ped. Sem.*, 33, 1926, 235-249.

[20]C. W. Bray, Transfer of learning, *J. Exper. Psychol.*, 11, 1928, 443-467.

[21]W. S. Hunter, Habit interference in the white rat and in human subjects, *J. Comp. Psychol.*, 11, 1922, 29-59.

(1) That visual guidance (post-visual degree) was highly effective in increasing the efficiency for the early acquisition stages of learning in a blindfold cul-de-sac maze (pencil type).

(2) That such results may be found even under conditions of 'undirected intention' on the part of those subjected to visual guidance.

(3) That there is indication that the attainment of a higher degree of efficiency may be reached in less time by actual practice on the maze than that to be effected by guidance.

(4) That under the conditions of the experiment there was interference only of a temporary nature by changing from right to left hand and that re-adjustment to a continuance of acquisition of the maze was rapid.

(5) That a statement similar to (4) may be made regarding a 180° change of position of the entire pattern.

(6) That interference with continued acquisition of the maze amounted to 40% as a result of a one-week interval. This, however, was only temporarily effective.

(7) That a large degree of variability is indicated for all parts of the maze work presented and as such appears to be a function of the type of learning such a problem involves.